

California Energy Commission

STAFF REPORT

DRAFT EVALUATION REPORT

2008 Building Energy Efficiency Standards

Proposed Compliance Option for Low-Sloped Roofs
That Use Aggregate as the Surface Layer



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ABSTRACT

California's 2008 *Building Energy Efficiency Standards* require that roofing products meet specific "cool roof" properties to help reduce building cooling loads by reflecting and emitting energy from the sun, reducing roof temperatures on hot sunny days, resulting in reduced energy use by air conditioning systems. These properties are aged solar reflectance and thermal emittance, and the standards require that each property must be tested, certified, and labeled according to provisions by the Cool Roof Rating Council. The Cool Roof Rating Council's procedures require that sample roof assemblies first be tested in a prescribed manner to determine the product's "initial" solar reflectance and thermal emittance, and then be tested again over a three-year period to establish the product's "aged" solar reflectance.

Aggregate materials are stone or gravel about $\frac{3}{4}$ inch or smaller that are a type of finish surfacing for some low-sloped roofs often used on nonresidential building construction. The aggregate is spread across the surface of a moisture-resistant membrane, as the finish layer of the "built-up" roof. However, sample roof assemblies that use aggregate as the surface layer cannot be transported to certified testing facilities without damage to the aggregate surface layer, which leads to test results for the cool roof properties that are worse than the performance that would be expected of actual roofs of this type that are installed on buildings.

Staff proposes that the Energy Commission approve a compliance option that establishes default aged solar reflectance and thermal emittance values to be used for roofs that use aggregate as the surface layer. The proposed default aged solar reflectance and thermal emittance values are based on site testing for the solar reflectance of aggregate installed on low-sloped roofs, and manufacturer's published values for the initial thermal emittance of aggregate.

The proposed default values for cool roof properties will allow a realistic assessment of "cool roof performance" for low-sloped roofs that use aggregate as the surface layer when showing compliance with the standards. The proposed default values for cool roof properties are representative of long-term performance as determined through on-site testing and are substantially higher than the default values currently allowed for approved alternative calculation method use.

Keywords: California Energy Commission, cool roofs, low-sloped roofs, solar reflectance, thermal emittance, *Building Energy Efficiency Standards*

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Introduction

This report presents the California Energy Commission staff's recommendation for a compliance option for low-sloped roofs that use aggregate as the surface layer. For compliance with the *2008 Building Energy Efficiency Standards*, the term "cool roof" refers to a roofing product with high solar reflectance and thermal emittance properties. These cool roof properties help reduce building cooling loads by reflecting and emitting energy from the sun, reducing roof temperatures on hot sunny days, resulting in reduced energy use by air conditioning systems. Both solar reflectance and thermal emittance are measured from 0 to 1; the higher the value, the "cooler" the roof. There are numerous roofing materials in a wide range of colors that have relatively good cool roof properties. The *Building Energy Efficiency Standards* specify that all roofing products shall meet minimum solar reflectance and thermal emittance values for showing compliance the standards.

The standards provide two methods of demonstrating compliance: prescriptive method, and performance method. With the prescriptive method of compliance every measure listed in Table 151-C, Component Package D of the *2008 Building Energy Efficiency Standards* must be met or exceeded for the building to be in compliance. The prescriptive cool roof requirements listed in this table are used in establishing the building energy budget that must be met for the building as a whole to show compliance with the performance method. When the performance approach is used, the energy effects of building features are analyzed to determine their overall affect on the building's total energy use. Individual energy measures of the building can be less than measures listed in Table 151-C, Component Package D, so long as other more energy efficient measures are used and the resulting building energy use exceeds the minimum energy compliance level established by the standards. The performance approach uses alternative calculation method compliance software approved by the Energy Commission.

The *2008 Standards* specify radiative properties that represent minimum "cool roof performance" qualities of roofing products:

- Solar reflectance—the fraction of solar energy that is reflected by the roof surface
- Thermal emittance—the fraction of thermal energy that is emitted from the roof surface

The *Building Energy Efficiency Standards* require that to gain compliance credit for "cool roof performance," roofing products must be tested and certified by the Cool Roof Rating Council (CRRRC). The CRRRC's procedures require that sample roof assemblies for all roofing products must first be tested in a prescribed manner to determine the product's "initial" solar reflectance and thermal emittance, then be tested again over a three-year period to establish the product's "aged" solar reflectance. Alternative calculation methods that are currently approved by the Energy Commission must use CRRRC-tested values for these cool roof properties or assume poor performing default assumptions when showing compliance with the standards. However, sample roof assemblies that use aggregate as the surface layer cannot be transported to certified

testing facilities, as specified by CRRC testing procedures for evaluation of their cool roof properties, without damage to the aggregate surface layer, which leads to test results for the cool roof properties that are worse than the performance that would be expected of actual roofs of this type that are installed on buildings.

Compliance Options

Public Resources Code, Section 25402.1 (b) requires the California Energy Commission to establish a formal process for certification of compliance options of new products, materials, or calculation methods for showing compliance with the *Building Energy Efficiency Standards*. Section 10-109 of the *Building Energy Efficiency Standards* allows for the introduction of designs, materials, or devices that cannot be adequately modeled in the currently approved alternative calculation methods or are not appropriately accounted for in the current approved compliance approaches.

The compliance options process allows the Energy Commission to review and gather public input regarding the merits of new compliance techniques, products, and designs, and to possibly approve their use. Compliance options enable new or additional products, materials, designs, or procedures to demonstrate compliance for newly constructed buildings and additions and alterations to existing buildings. Approved compliance options encourage market innovation and allow the Energy Commission to respond to changes in building design, construction, installation, and enforcement.

Staff Evaluation

Aggregate Roofing Materials

The *California Building Code* (CBC) describes aggregate used as surfacing for roof coverings as crushed stone, crushed slag, or water-worn gravel.¹ Stone, aggregate and gravel materials are often used as the finish layer for built-up roofs. They are used on flat or “low-sloped” roofs, most often seen in commercial building construction. Crushed aggregate and gravel used as surfacing on low-sloped roofs is typically between ¼ to ¾ inches and spread across the roof surface.² This differs from stone and larger aggregate used on ballasted roofs, which use larger stones (typically 1 ½ to 2 ½-inches) and concrete pavers to provide sufficient weight to hold down single-ply roofing membranes without mechanical fastening.

1 2010 *California Building Code*, Title 24, Part 2, Volume 1 of 2, Section 1502.1.

2 ASTM C136, *Standard Method for Sieve Analysis of Fine and Coarse Aggregates*; ASTM D1863, *Standard Specification for Mineral Aggregate Use on Built-Up Roofs*.

Aggregate roofing materials are spread across the top of a water-resistant membrane installed on the roof. In some cases, the water-resistant membrane may be liquid asphalt or other sealant installed through “hot mopping”; in this case, the aggregate becomes embedded in the asphalt, and a light overlay of loose aggregate is applied over the roof surface to provide longevity to the installed roof system. It’s not uncommon to see aggregate used on rooftops of schools and hospitals as an example. The color of the aggregate depends on the stone from which it is quarried. Aggregate that is to be used as roof surfaces is crushed to specified sizes and may be placed in a furnace to remove moisture and to dry-finish coatings.

Specifications for stone and aggregate roofing materials are based on a size classification defined by ASTM International: ASTM D448, *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*, and ASTM C136, *Standard Method for Sieve Analysis of Fine and Coarse Aggregates*. Rock and aggregate are dropped through different sieves to determine their size. Size No. 4 is typical of ballasted roofs; whereas aggregate and gravel, which is smaller, is typically size No. 6 and No. 7. The *California Building Code* references these standards for roofs that use aggregate as the surface layer and for ballasted roofs. In the case of built-up roofs, the CBC further defines size and quality by reference to ASTM D1863, *Standard Specification for Mineral Aggregate Used on Built-Up Roofs*. Construction documents will specify the aggregate or rock size when these roof types are used.

Cool Roof Rating Council

To qualify for energy credit when showing compliance with the *Building Energy Efficiency Standards*, Section 118(i) requires roofing products to be tested, certified, and labeled according to procedures of the Cool Roof Rating Council (CRRC). To receive a product rating by the CRRC, the manufacturer or company that sells the finished product must:

1. Become licensed with the CRRC.
2. Send product samples to a CRRC accredited independent laboratory for testing to determine the product’s initial solar reflectance and thermal emittance based on the product’s performance qualities for coating type, membrane thickness, and color.
3. Send the same finished laboratory testing samples to an approved CRRC test farm to complete the three-year weathering test to determine the product’s aged solar reflectance.

The CRRC’s Rated Products Directory includes 11 product types, including but not limited to sheet goods (single-ply roofing products), shingles and tiles (asphalt, concrete, clay or metal), metal roofing panels, and factory- and field-applied coatings. The size and other characteristics of samples to be sent to CRRC testing facilities for performance testing depend on the type of roofing product. In all cases, the company requesting the product rating is responsible for the cost of testing and ensuring product samples arrive at test facilities in a condition representative of the finished product.

For each “Standard Roof Product” to be tested, manufacturers must prepare a total of nine samples randomly selected from two batches representing the finished roofing product. Upon completed testing for the initial solar reflectance and thermal emittance, three of the product samples are then shipped by the testing laboratory to each of the three approved CRRC test farms for completion of three-year aged exposure testing.³ The three roof exposure testing farms are regionally located across the country, representing hot-humid, cold-temperate, and hot-dry climate zone conditions.

Aggregate materials are tested for their aged solar reflectance using the pyranometer testing procedures of ASTM E1918, *Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field*. A pyranometer is an instrument to measure the amount of solar irradiance (the power of electromagnetic radiation) on a surface. Pyranometers are frequently used in meteorology, climatology, solar energy studies and building physics. The CRRC’s test method requires product test samples to be at least 4 meters on each side (about 13 ft on each side, or about 172 sq. ft.). A typical built-up roof test sample with embedded aggregate including a light overcoat weighs roughly 130 lbs. or more per sample. The sheer size and overall weight of the CRRC-required three samples that must be sent to three facilities across the country demand that each sample is mechanically loaded and unloaded from each freight truck. It is unlikely that the samples will arrive at test facilities without dislodging aggregate and exposing the substrate below. In this condition the sample will not be representative of the finished product as installed on actual roofs. As a consequence, manufacturers that provide aggregate as cool roof covering for low-sloped roofs have difficulty in establishing realistic product performance ratings for aged solar reflectance following CRRC procedures.

On-Site Testing of Aggregate Roofing

In the spring of 2012, the Heat Island Group at Lawrence Berkeley National Laboratory (LBNL) measured the in-situ (in its original place) solar reflectance of roofs covered with aggregate, which had been installed for periods ranging from 1 to 20 years. Measurements were taken at four sites in the Los Angeles basin on March 26-28, 2012. This study sought to determine the solar reflectance of limestone aggregate, sold by A-1 Grit Company as 3/8” Natural White Rock (aka “white marble”), and the extent to which the solar reflectance diminishes over time. The study was conducted following ASTM Standard E1918-06, *Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field*. The measured solar reflectance ranged from about 0.48 to 0.52. Even though measurements were taken of aggregates quarried from different sites and at different times, and roof solar reflectance measurements were in somewhat different environments within the greater Los Angeles basin, measurements indicate that the aggregate retains a solar reflectance of about 0.50 over a 20-year period.⁴

3 Cool Roof Rating Council, Product Rating Program, CRRC-1.

4 See full report: Pablo, Melvin Pomerantz, Ronnen Levinson (Lawrence Berkeley National Laboratory). 2012. *Solar Reflectance of Roofs Covered with Mineral Aggregate Surfacing Material*. (<http://www.energy.ca.gov/2012publications/CEC-500-2012-083/CEC-500-2012-083.pdf>)

Proposed Compliance Option

Staff proposes that a default aged solar reflectance and thermal emittance be used for aggregate roofing materials installed on low-sloped roofs for showing compliance with the *2008 Building Energy Efficiency Standards*. The proposed default values and eligibility criteria will enable manufacturers to use cool roof properties that are representative of the performance of aggregate installed on actual roofs for showing compliance with the standards, rather than being required to use default values that are substantially worse than in-situ measured performance.

Proposed Default Reflectance Values

Based on the findings of the LBNL study discussed above, staff proposes that low-sloped roofs that use aggregate as the surface layer have the following default cool roof property values:

- An aged solar reflectance of 0.50
- A thermal emittance of 0.85

Proposed Eligibility Criteria

Manufacturers' use of these default cool roof property values must demonstrate that their aggregate material meets the eligibility criteria listed below:

1. Conforms to material standard ASTM D1863.
2. Conforms to ASTM D448, size number equal between No.6 and No.7.
3. Has a CRRC-tested initial solar reflectance that meets or exceeds 0.55 using the ASTM E1918 test procedure with aggregate passing a No. 4 sieve and is retained by a No. 8 sieve that conforms to ASTM D448, conducted by a CRRC accredited independent laboratory meeting the requirement of Section 10-113(d)4 of the *Building Energy Efficiency Standards*.
4. Has a label on bags or containers of aggregate stating that the materials conform to ASTM D1863 and ASTM D448.

Conclusion

Staff recommends that default aged solar reflectance and thermal emittance values be allowed for showing compliance with the *2008 Building Energy Efficiency Standards* for low-sloped roofs using aggregate as the surface layer, when the aggregate meets specific eligibility criteria. Allowing the proposed default aged solar reflectance and thermal emittance provides realistic cool roof properties to be used for these roofs rather than the substantially lower default values allowed for use with the current prescriptive or approved performance compliance alternative calculation methods.

Staff invites the public's review and stakeholder comments on the proposal contained in this draft evaluation report. Comments can be by e-mail and electronic submission, up to 5 MB. Comments should be in a downloadable, searchable format such as Microsoft® Word (.doc) or Adobe® Acrobat® (.pdf). For additional information, see Standing Order re: Proceedings and Confidentiality Procedural Requirements for Filing, Service, and Docketing Documents with the Energy Commission, available at:

www.energy.ca.gov/dockets/documents/2011_Standing_Order_for_Documents.pdf.

Please include the docket number 12-BTSD-7 and indicate "Compliance Option for Low-Sloped Roofs that Use Aggregate as the Surface Layer for Showing Compliance with the 2008 Building Energy Efficiency Standards" in the subject line. Send comments to: docket@energy.ca.gov.

Staff will conduct a Webinar on December 18, 2012 to discuss this report and staff's compliance option recommendations. A notice for this Webinar can be found at www.energy.ca.gov/title24/2008standards/special_case_appliance/.